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The interactive whiteboard and the instructional design in teaching physics

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Abstract

Our students have to understand that Physics is not only about memorizing and calculating. If the cognitive load theory is applied when teachers are developing their lesson projects, the questions and the evaluation forms, then they are able to better monitor their students' understanding. The interactive Smart Board is an excellent way of learning, being an instrument used by teachers for both teaching lessons as well as for grading students. The cognitive load theory can be applied in teaching Physics more easily when we are using the Smart Notebook 10 software because the material in a lesson can be presented in a more interactive way. The present paper's purpose is to present the way in which teachers can promote an interactive learning and stimulate students' creative potential, by using the interactive whiteboard and the cognitive load theory.

Keywords: The human cognitive architecture, cognitive load theory, interactive learning, software, Smart Board – a new pedagogical tool within Physics education

1. Introduction

The division of science into disciplines and sub-disciplines which are taught separately, without the organic links between them being highlighted, makes the knowledge-eager young person become bored with abstract things and think of school as being only a necessity to obtain a diploma, instead of a knowledge and improvement source. The conclusion, which is self-implied, is that the current educational system needs to be transformed and the way of transmitting-receiving information needs to be modified. If we refer strictly to the Physics learning process, this type of system does not offer a powerful enough motivation to students, leaving most of them confused as far as the basics concepts are concerned. Most students think that too much effort is needed to learn Physics, contrary to the perspectives it can offer (Alarcon, 2005). In the current system, either high school or college, where Physics is taught in the first year at an introductory level, the teacher presents the material, solves examples or problems at the blackboard and sometimes makes laboratory demonstrations. The pupils and students listen to the lecture, take

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notes, but seldom ask questions or make comments. In the best cases, pupils and students make some Physics experiments where they follow known paths to obtain the confirmation of some already-known results. This type of learning process focused on the teacher involves little active learning and makes pupils and students lose their motivation to learn and also to become passive into the knowledge-gaining process and creates an image that Physics is only focused on memorizing and mathematical calculus and contributes to picking wrong strategies when later solving problems (Taasoobshirazi & Carr, 2008). Under these conditions, it is clear that the students have limited possibilities for understanding the subject, the education curriculum stressing more on memorizing than understanding. Using interactive methods can improve the efficiency of classes. This type of methods seeks the mingling of teacher's strategy with the student's learning style (Alarcon, 2005).

2. The Human Cognitive Architecture and Cognitive Load Theory

2.1. The Human Cognitive Architecture Styles

The human cognitive architecture contains sensory memory, working-memory and long-term memory (model proposed by Atkinson and Shiffrin, 1968). The sensory memory is made up of three registers: acoustic, visual and tactile (Crahay, 2009). Stocking the external information in the structure of previous knowledge is produced at the level of working-memory. For this to be done, the knowledge stored into the long-term memory must be recovered and brought into the working-memory (Crahay, 2009). An important characteristic of the working-memory is that it is limited both as capacity and as duration when new information is processed. According to Miller (Miller, 1956), the working-memory can hold 7(+/-2) items or chunks of information (Miller, 1956). The chunk of information depends on the knowledge structure. Introduced into the long-term memory, a link of concepts occupies a single chunk of information (Crahay, 2009). The knowledge is stored into the long-term memory as schemes. These schemes contribute to the growth of the working-memory capacity. According to Sweller (Sweller, van Merrienboer & Paas, 1998), the schemes can have two functions: organizing and stocking information into the long-term memory according to the method they will be used to fulfill a task and the extension of working-memory. Even though schemes are stored into the long-term memory, their construction appears into the working-memory. Hence it raises the necessity of a better organization of knowledge. Automation is another critical component of the schemes construction. It happens when the information stored in schemes can automatically be processed without conscious effort (Artino, 2008). Construction of schemes and automation must be taken into consideration in the learning process (Artino, 2008).

2.2. Cognitive Load Theory

Cognitive load theory can be defined as a learning and instructional design of principles theory, based on human cognitive architecture (Elliot, Kurz, Beddow & Frey, 2009). This theory is based on two main learning mechanisms, one referring to the acquisition of the schemes and other referring to automation. The function of these mechanisms is to reduce the cognitive load into the working-memory, so as it will be capable of processing large sets of information (Chanquoy, Tricot & Sweller, 2007).

Types of cognitive loads

The cognitive load theory takes into consideration three types of cognitive loads:

1. ***Intrinsic Cognitive Load*** – refers to the number of elements which need to be treated simultaneously in the working-memory to build the schemes. It is determined by the complexity of the content to be presented and the interactivity grade between the elements (Dillenbourg & Betrancourt, 2006). If the material contains a large number of interactive elements, the learning and understanding will be complex. In this case it is better that the material is presented in two stages: first the separate elements and then the integrated ones (Chanquoy, Tricot & Sweller, 2007).

2. ***Extraneous Cognitive Load*** – is the result of the instruction methods which ask the student to engage into activities which are not directly linked to the construction and automation of schemes in the working-memory (Sweller, 1994). Extraneous cognitive load is due to an inefficient presentation of the instruction material, or some parallel activities which the person can make, if the intrinsic cognitive load is complex. (Artino, 2008). For a complex subject such as Physics, where there are several elements of interactivity, these must be processed simultaneously, which makes a large intrinsic load. It is important that the learning material and the methods used to present the information be carefully planned, so as to not introduce additional elements (Sweller, 1994).
3. ***Germane Cognitive Load*** is the load which appears when the construction and automation of the knowledge schemes are produced in the working memory.

The cognitive load theory has generated in the last years educational methods in order to reduce extraneous cognitive load and to enlarge the germane cognitive load under the conditions of a large intrinsic cognitive load (Artino, 2008). Freeing the capacity of the working-memory by diminishing the extraneous cognitive load is not sufficient for an effective learning. It is necessary to create a balance between the intrinsic cognitive load and the germane cognitive load (Kirschner, Kester & Corbalan, 2010).

3. Interactive whiteboard – interactive tool and application of cognitive load theory for learning and teaching Physics in high school

By using these theories, educational material can be projected in order to facilitate the access to information in the field of Physics. In order for a student to understand and assimilate the materials presented, it is important for teachers to consider each student's cognitive capacity and limit when preparing a lesson (Fillmore & Tuovienen, 2008). Teachers have to reconsider their objectives and should always be careful to find the most proper lesson projects, questions and evaluation forms, which contribute to monitor students' understanding (Salavastru, 2004). The interactive whiteboard can be one of the best technological tools for students to understand the complexity of Physics phenomena. Notebook 10, the software of the interactive "Smart Board", offers a wide range of opportunities for the training to be done in a variety of ways. Thereby, information such as text, images, diagrams, animations, educational films and sites can be seen as a form of visual methods. The Image Gallery consists of several graphic elements like: title boxes, text boxes, images related to almost every chapter in Physics, as well as tests samples. Moreover, an acoustic way of learning can also be approached – for instance, presenting sounds made by different instruments. A third approach is a tactile one, which allows students to interact with the board without actually being at a computer. To the extent that these methods are integrated into the lesson, in a way that takes into account the limits of the students' working-memory capacity, the active participation of students in building their own knowledge can be established. The interactive whiteboard permits students to acquire new information about the world, which arouses their interest and contributes to the development of scientific concepts (Dhindsa & Emran, 2006). A way of overcoming the limits of the individual working-memory is collaborative learning. Student groups are seen as information processing systems. Intrinsic cognitive load and the required information to fulfill a learning task can be divided into several working-memories of the group members. In this way the capacity of the individual working-memory is released and the capacity of the working-memory of the entire group is extended (Kirschner, Paas & Kirschner, 2009). It has been proved that students are more motivated and more enthusiastic when team-working. Collaborative learning can be used to elaborate conceptual micro-maps, which can be visualized and completed on the interactive whiteboard. The dual coding theory (Paivio, 1986) suggests that concept maps can ease learning if they incorporate labeled nodes drawn as different images which can help the student remember previous knowledge about concepts (Nesbit & Adesope, 2006). Figure 1 represents a concept map of the eye used as an optical instrument, map done by using Smart Ideas 5 software. It consists of a central map and two other maps which show the defects of vision: myopia and hyperopia, made by several student teams. The comments on the relation between the concepts are made both by the teacher and the students. The teacher's role is to point out the deficiencies, to ask and answer questions and to involve even the less-active students in the learning process allowing the addition of images from its gallery as resources and also the making of micro-maps on the same subject. Having the software installed on the laboratory computers, the students work on the concept maps in groups of three, using several information sources, which are presented on the interactive whiteboard in an organized manner. The maps can be saved and used for further editing by adding new concepts and links (Stoica, Miron & Jipa, 2010). Creativity and imagination are stimulated through visual representations of knowledge. Students who collaborate when performing complex activities are more confident about the success of their tasks than those who work individually (Kirschner, Kester & Corbalan, 2010). The interactive whiteboard is a tool which permits collaborative learning (Kolfschoten, Frantzeskaki, de Haan, Duivenvoorde & Verbraeck, 2009).

The interactive whiteboard can be used for the visualisation of data and graphics obtained in a computer-assisted experiment. In such an experimental activity, the student has the possibility to observe the real-time evolution of a physical quantity. Figure 2 shows the Hooke's Law experimental graphic of the dependency of deforming force on the spring elongation and figure 3 shows the same graphic obtained by data processing using a SciDAVis software during the same real experiment. Depending on the visual presentation of the graphics, the teacher and the students verbally comment the results which were previously obtained (for instance, the slope).

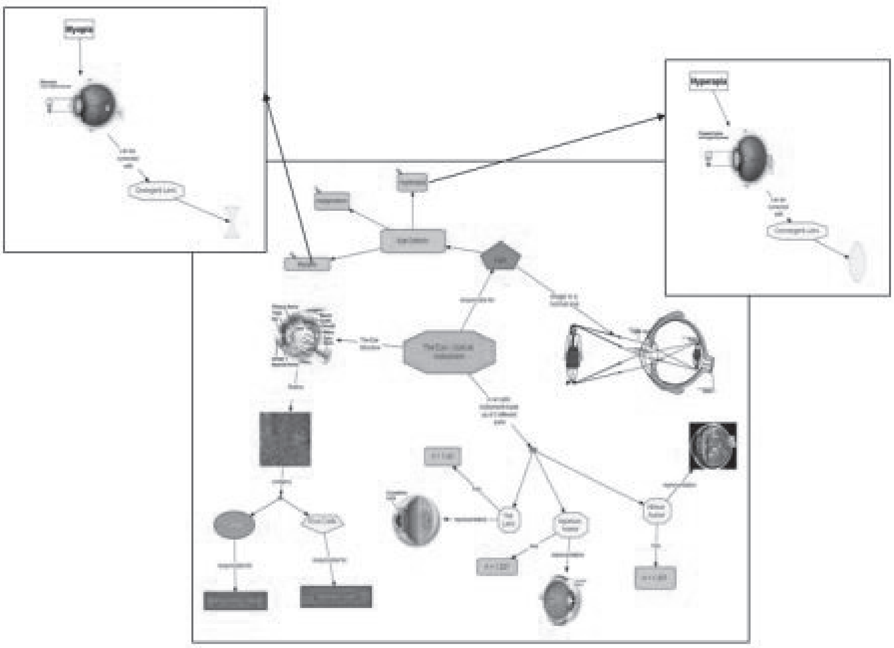

Figure 1. Concept map – The eye as an optic instrument

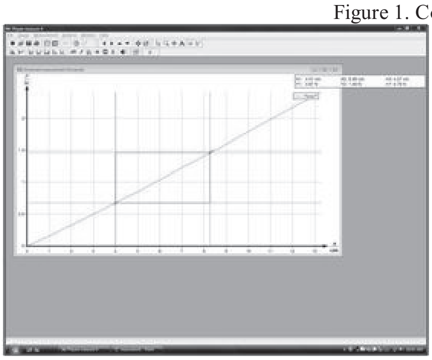

Figure 2. Graphic representation of the deforming force depending on the spring elongation in the Hooke's Law calculator assisted experiment

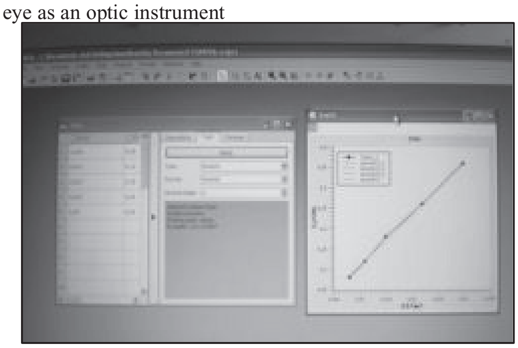

Figure 3. Graphic representation of the deforming force depending on the spring elongation in the Hooke's Law experiment using SciDAVis software (real experiment)

Cognitive load theory can provide guidelines to assist in the presentation of information in a manner that encourages learning. Extraneous cognitive load can be reduced to a minimum through an adequate presentation of the material (Dillenbourg & Betrancourt, 2006).

In this paper, we have tried to describe how the interactive whiteboard can be used during Physics classes, so as to value the opportunities offered by this interactive tool, while taking into account the cognitive load theory.

It was concluded that the interactive whiteboard has many advantages for teachers who use it as a teaching instrument. These advantages include the ability to manipulate objects in real time, efficiency in presenting a lesson and support for the long-term planning and use of resources. Students can benefit from these files with everything that has been previously visualised enriched with web documents. From discussions with the students who participated in this experiment, we have concluded that the classes where the interactive whiteboard was used were very interesting for the students. This highly arouses their interest and even motivates them. The interactive whiteboard contributes to the growth of interaction between students while performing a task, as shown in other works (Kolfschoten, Frantzeskaki, de Haan, Duivenvoorde & Verbraeck, 2009). Even if this study is only a qualitative one, some of the conclusions can be used in the next studies using interactive whiteboard for teaching Physics.

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